Technology Development for Autonomous Sampling and Return Missions

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Hydrothermal Vents

Locations of Known Vents (c. 1995)

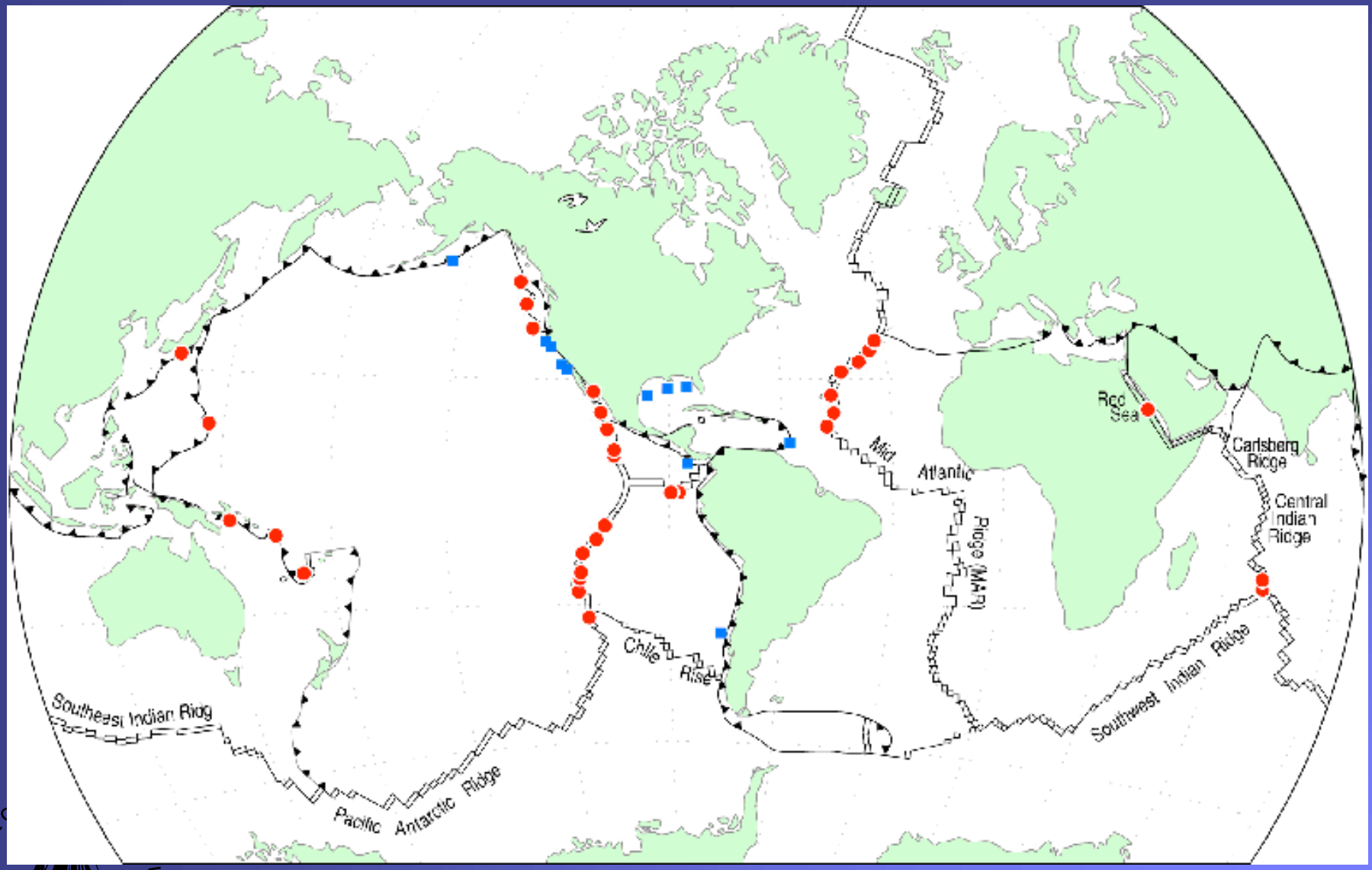
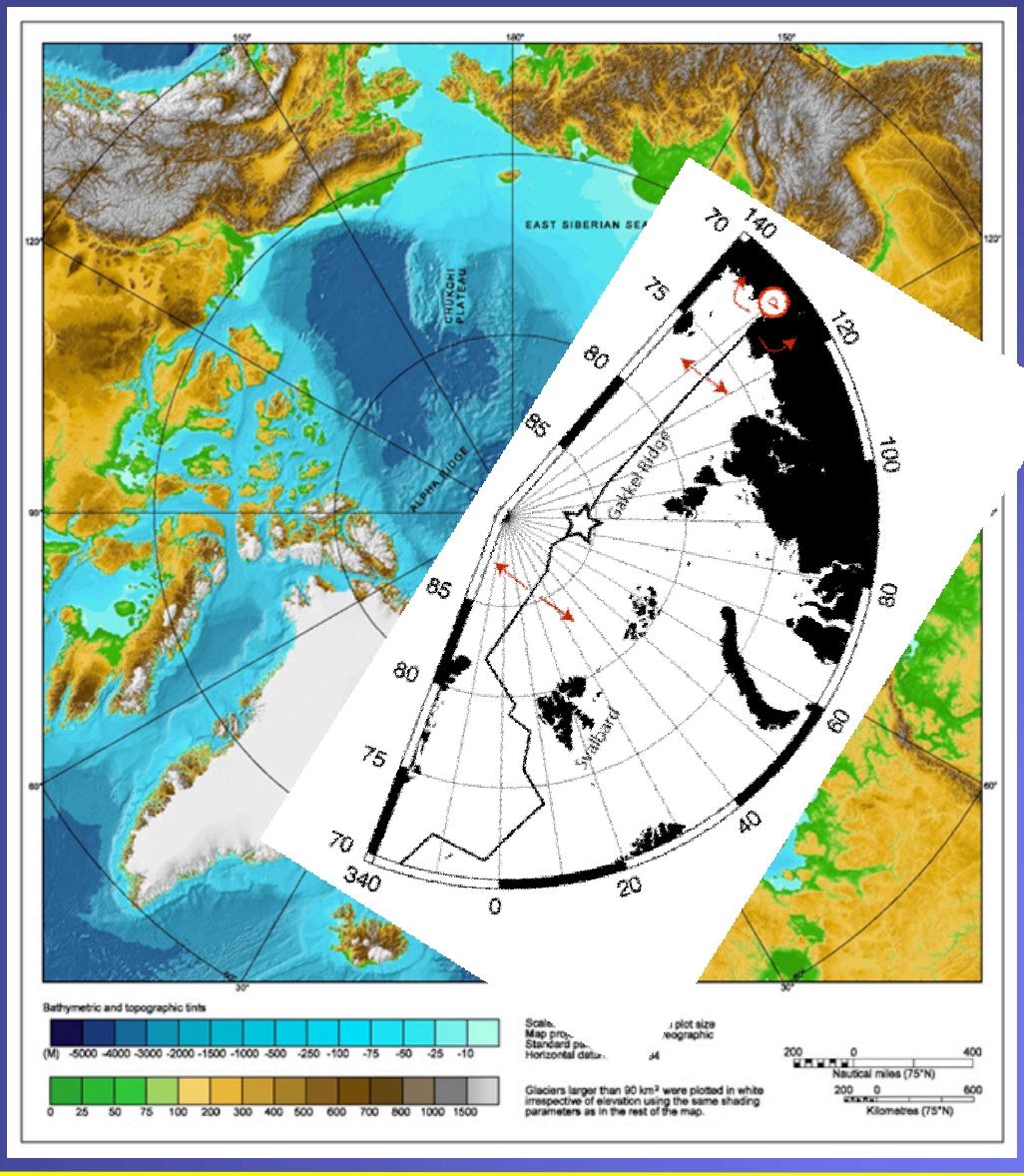
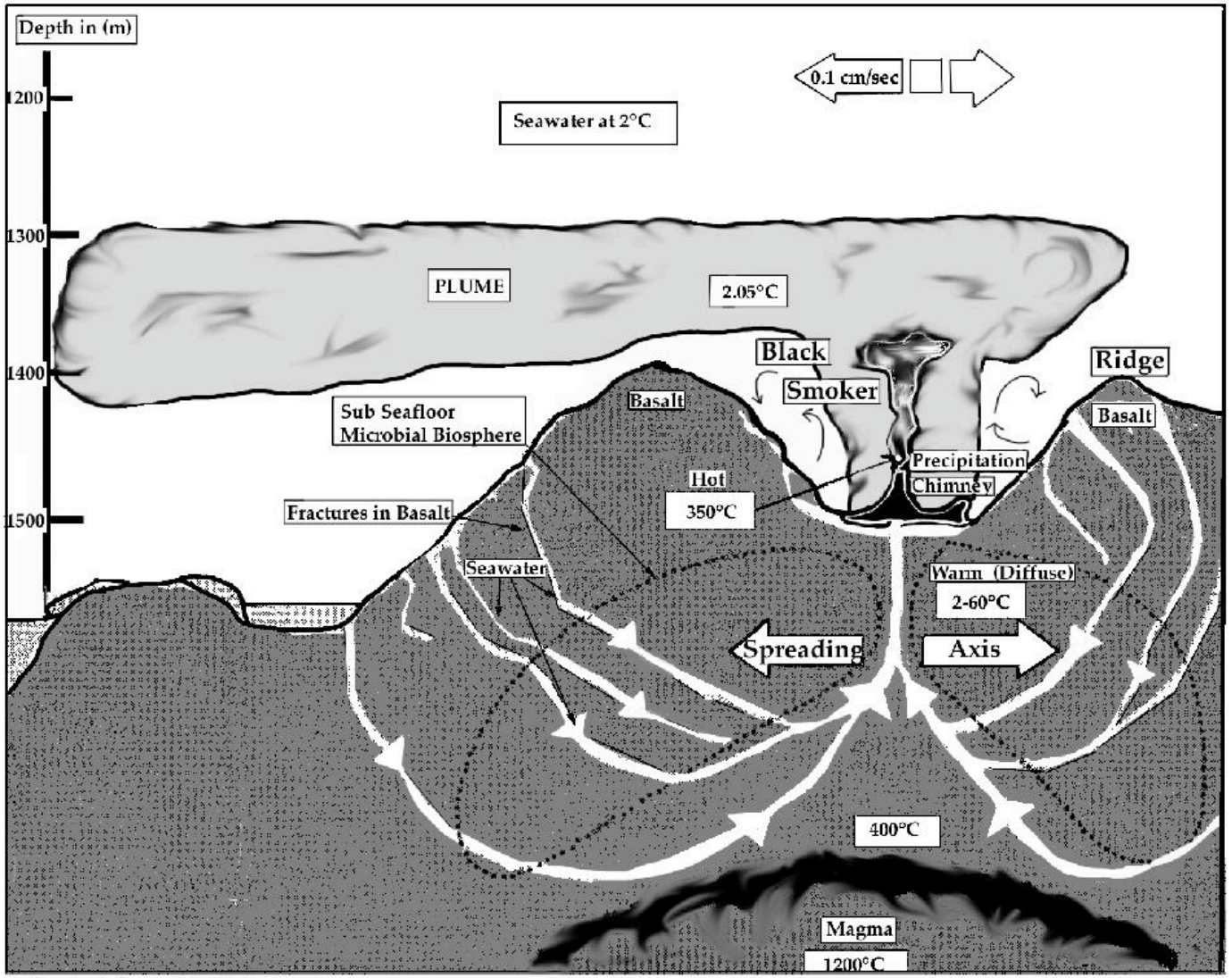


Plate Structure in the Arctic Ocean

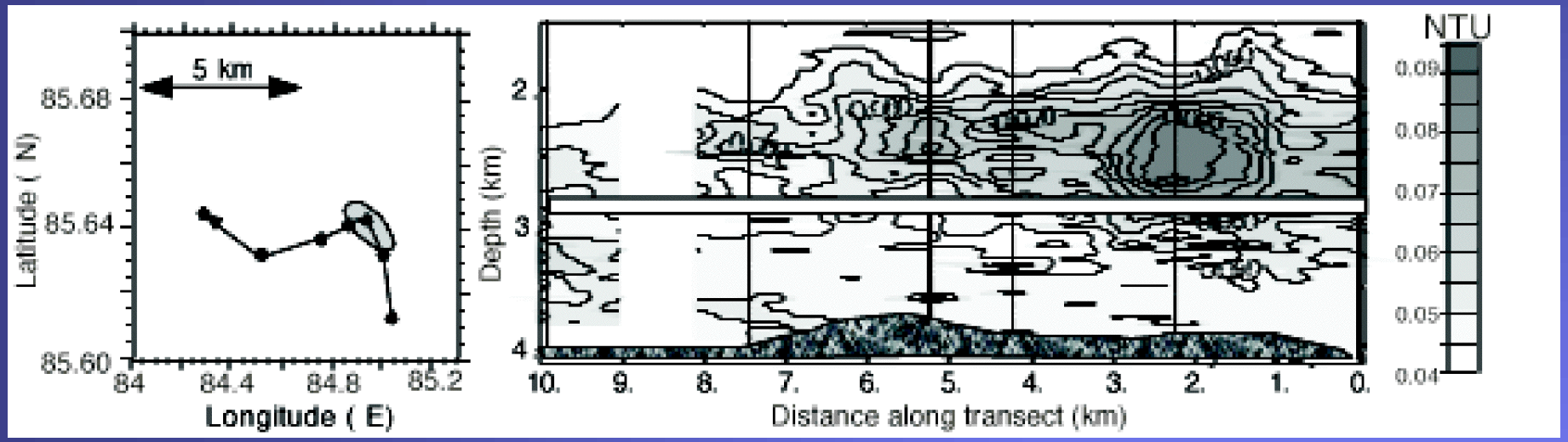


Hydrothermal Vent Structure



Adapted from NOAA Vent Diagram

AMORE 2001 Optical Transects



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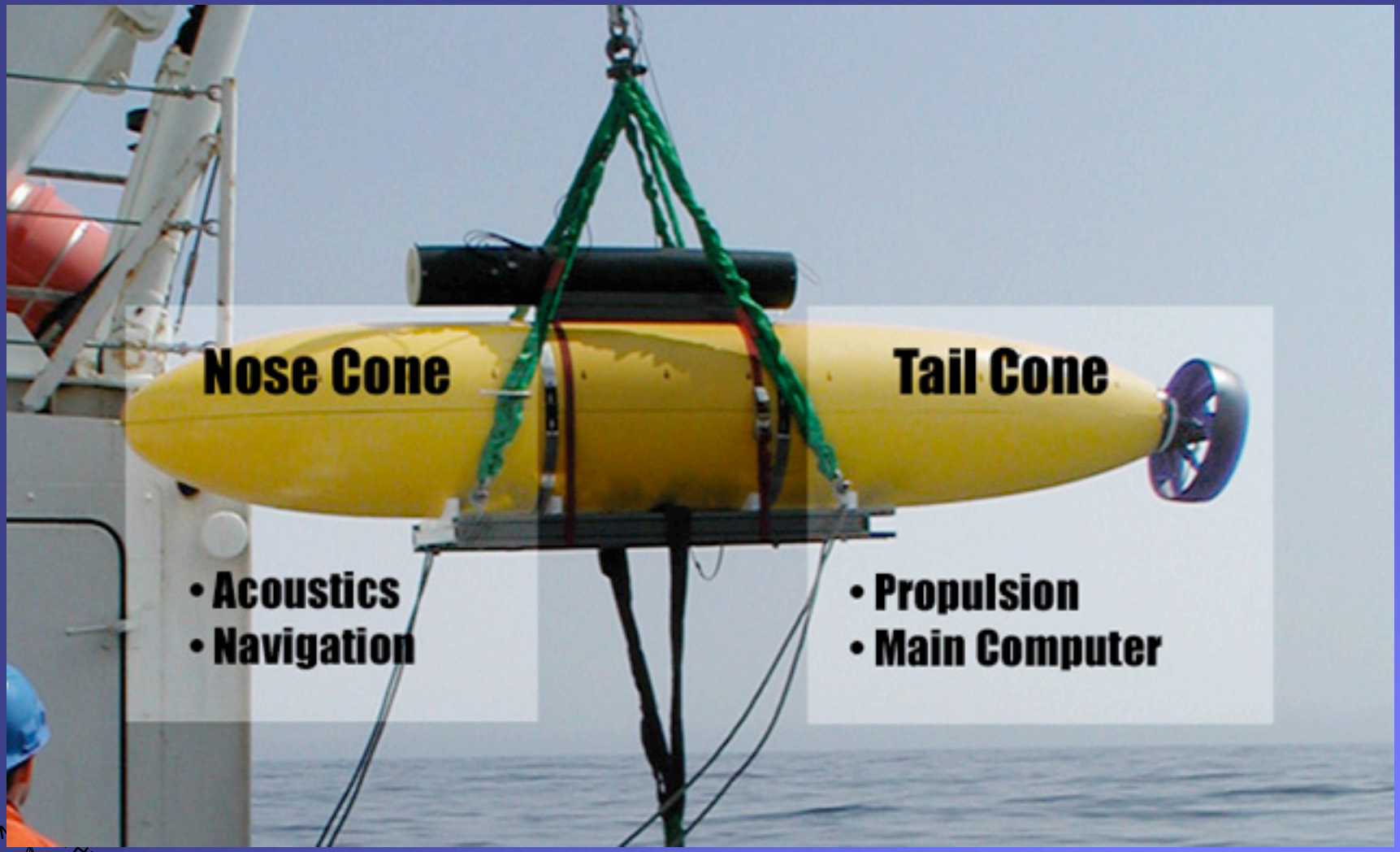
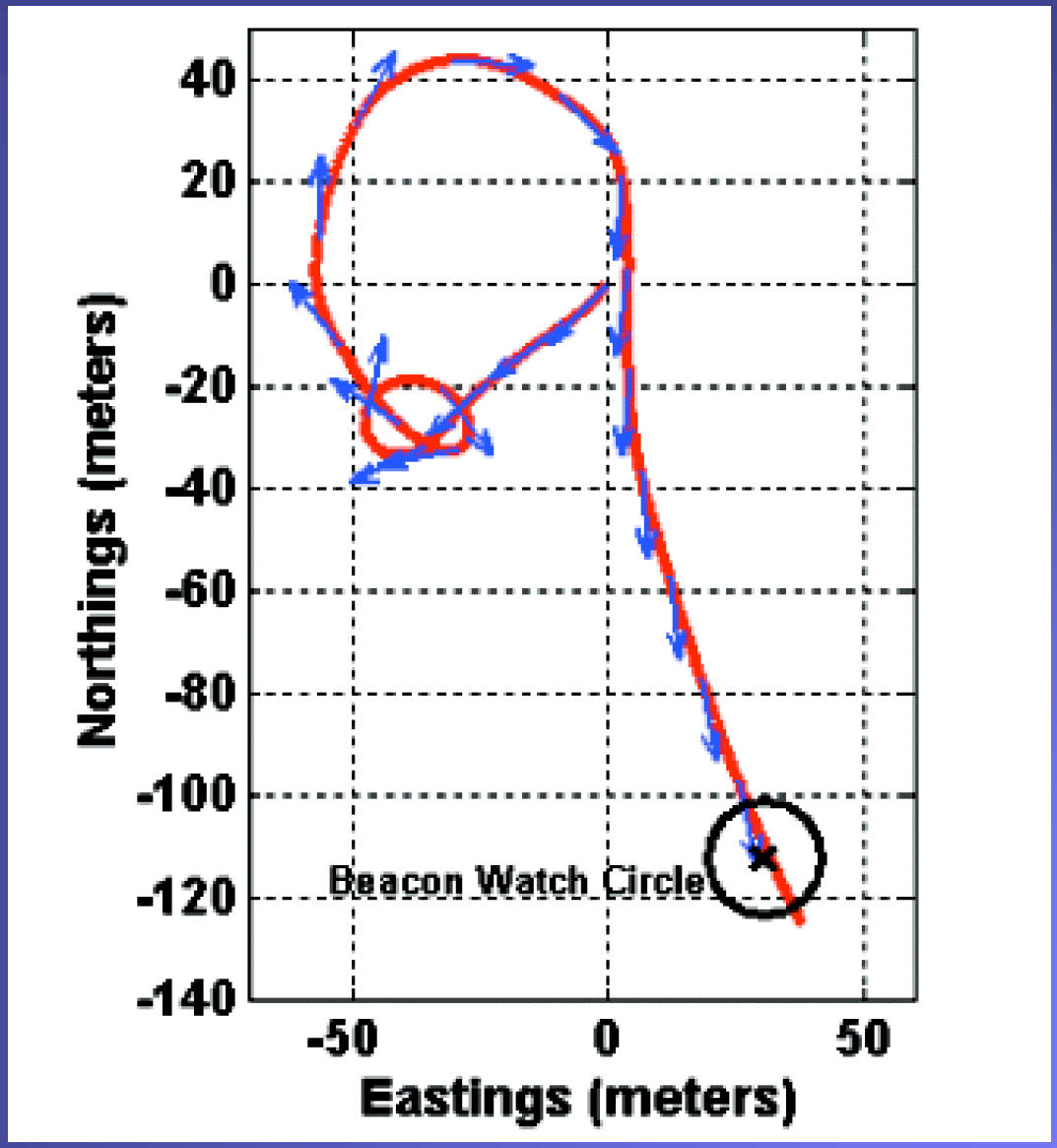
APOGEE AUV


Nose Cone
Tail Cone
• Acoustics
• Navigation
• Propulsion
• Main Computer

APOGEE Characteristics

- Depth Capability 4500 meters
- Size 2.3 m (L), 0.53 m (D)
- Mass ~200 kg in air (payload dependent)
- Operating Speed 1.5 m/sec
- Batteries 2kWhr Li-ion pack
- Propulsion 50 N actuated/ducted
- Navigation and Attitude System
  - Attitude+Heading Crossbow AHRS
  - Depth Paroscientific pressure sensor, 0.01%
  - Homing Utility Acoustic Modem, phased USBL, transducers
- Sensors
  - Seismometer Guralp 3TNSN
  - Diff. Pressure "Webb" custom broadband

APOGEE Tracking Task



SeaBED AUV

- Depth Capability 2000 meters
- Size 2.0 m (L), 1.5 m (H), 1.5 m (W)
- Mass ~200 kg in air (payload dependent)
- Operating Speed 1.5 m/sec (est.)
- Batteries 2kWhr Li-ion pack
- Propulsion Four DC thrusters: Fore 100 N, lateral 50 N, vertical 50 K
- Position LBL + 300 kHz RDI navigator, 0.1-1.0 m
- Electronic Camera Pixelfly 12 bit 1280x1024 CCD
- Sidescan Sonar MST 300 kHz (300 m altitude capability)

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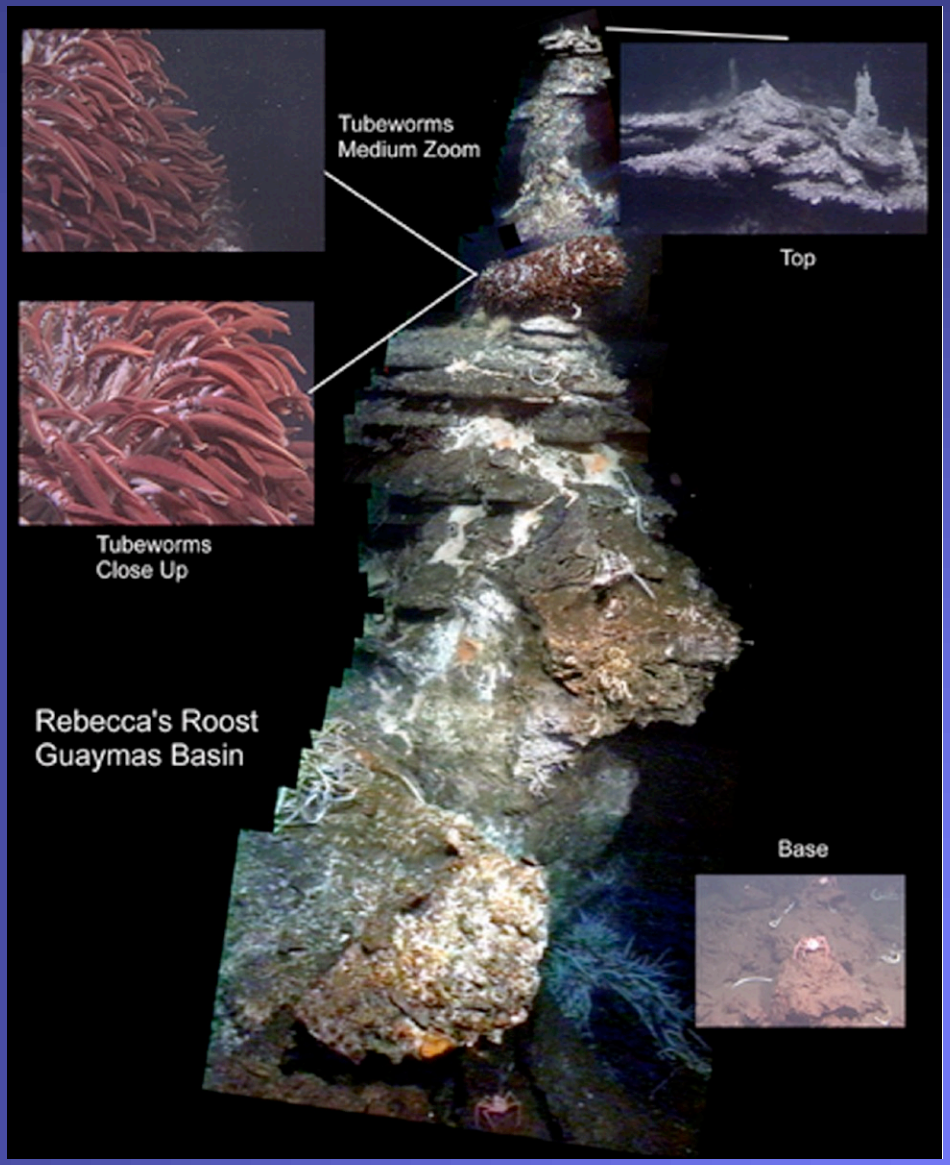
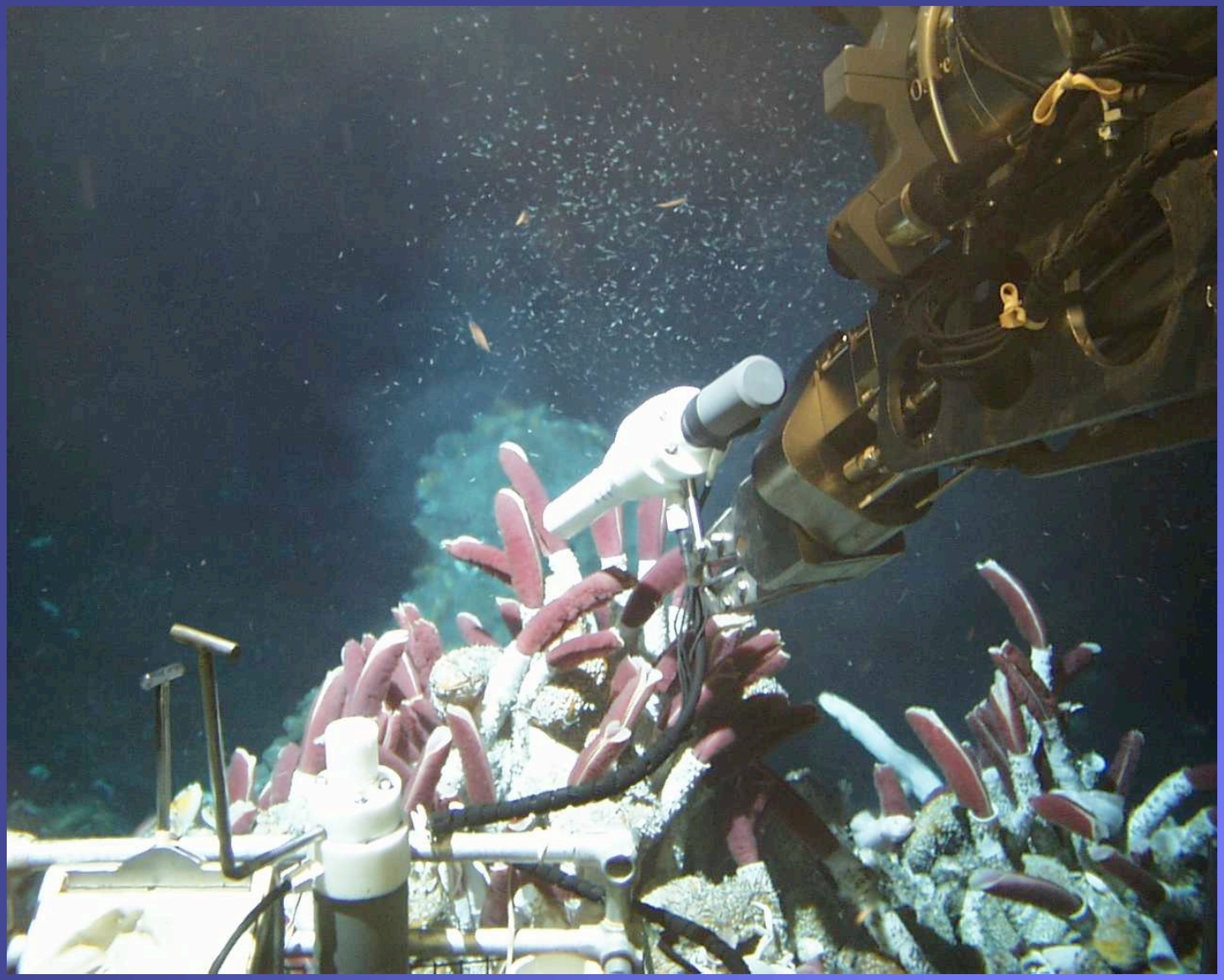
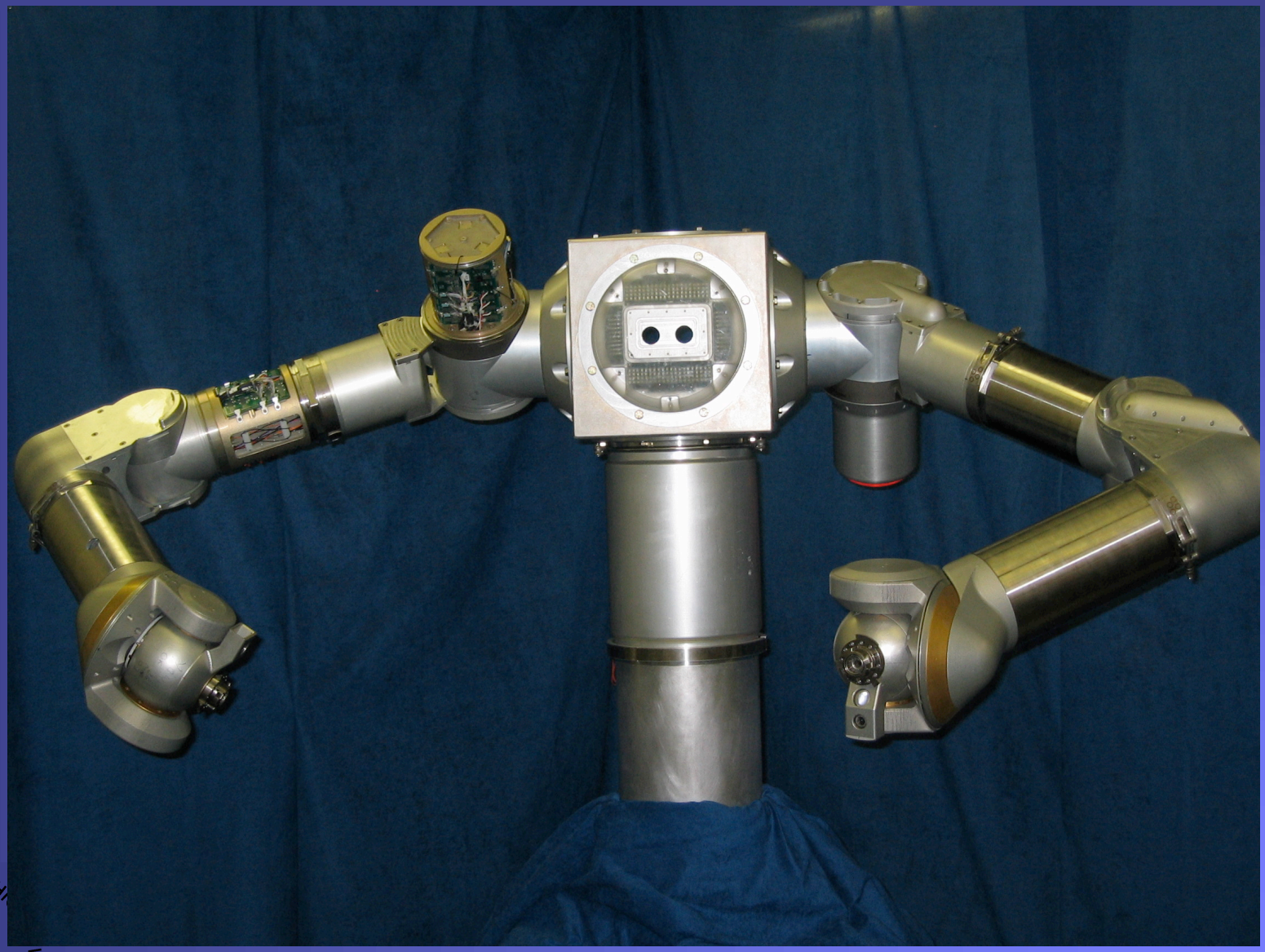
Vertical Mosaic of Vent Chimney



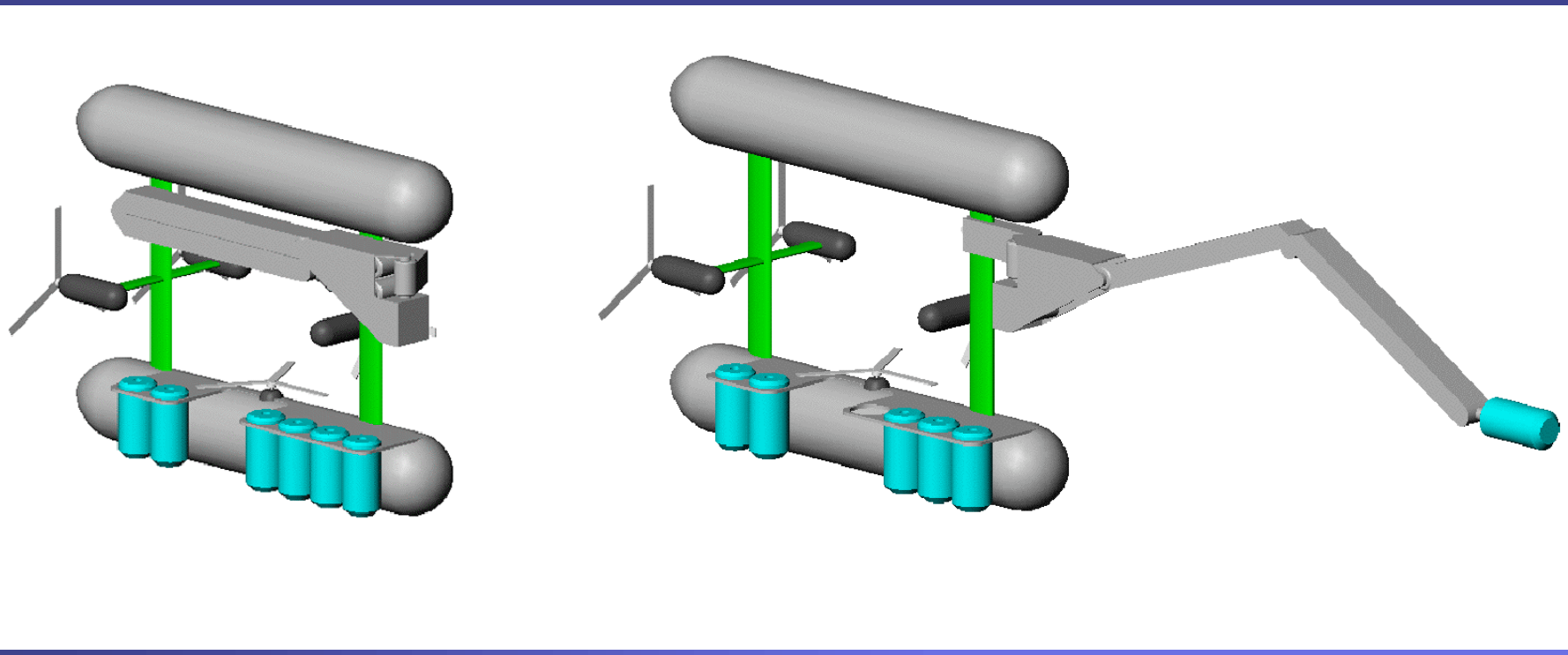
Vent Sampling



Ranger Flight Dexterous Arms



Addition of Sampling Arm to SeaBED

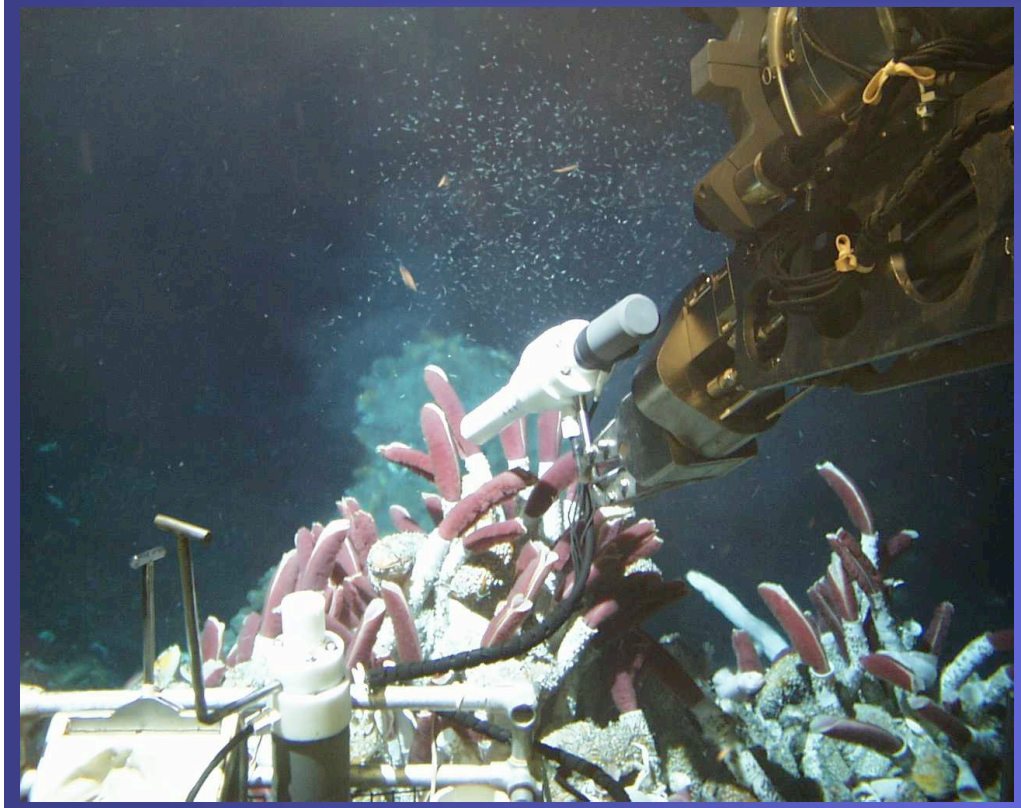


- Adaptation of Ranger dexterous manipulator for deep submergence (pressure-compensated oil purge)
- Gross mass limit 100 lb; buoyancy limit 10 lbs
- Coordinated autonomous control of arm and vehicle

Challenge: Autonomous Operations

- Deploy and calibrate (and ultimately retrieve) long-baseline acoustic (300 kHz) navigation system (3 beacons)
- APOGEE and SeaBED missions are “fire and forget” - navigate to site, take data/samples, return to icebreaker
- APOGEE works in 1 km^2 target area, takes optical/thermal transects at 20-60m spacing
- Locates prime sites for SeaBED sorties
- SeaBED moves to plume, navigates to source(s)
- Mobility around vents based (primarily) on visual inputs
- Goals for physical sampling: geological, biological, vent fluids

Challenge: Hydrothermal Vent Sampling



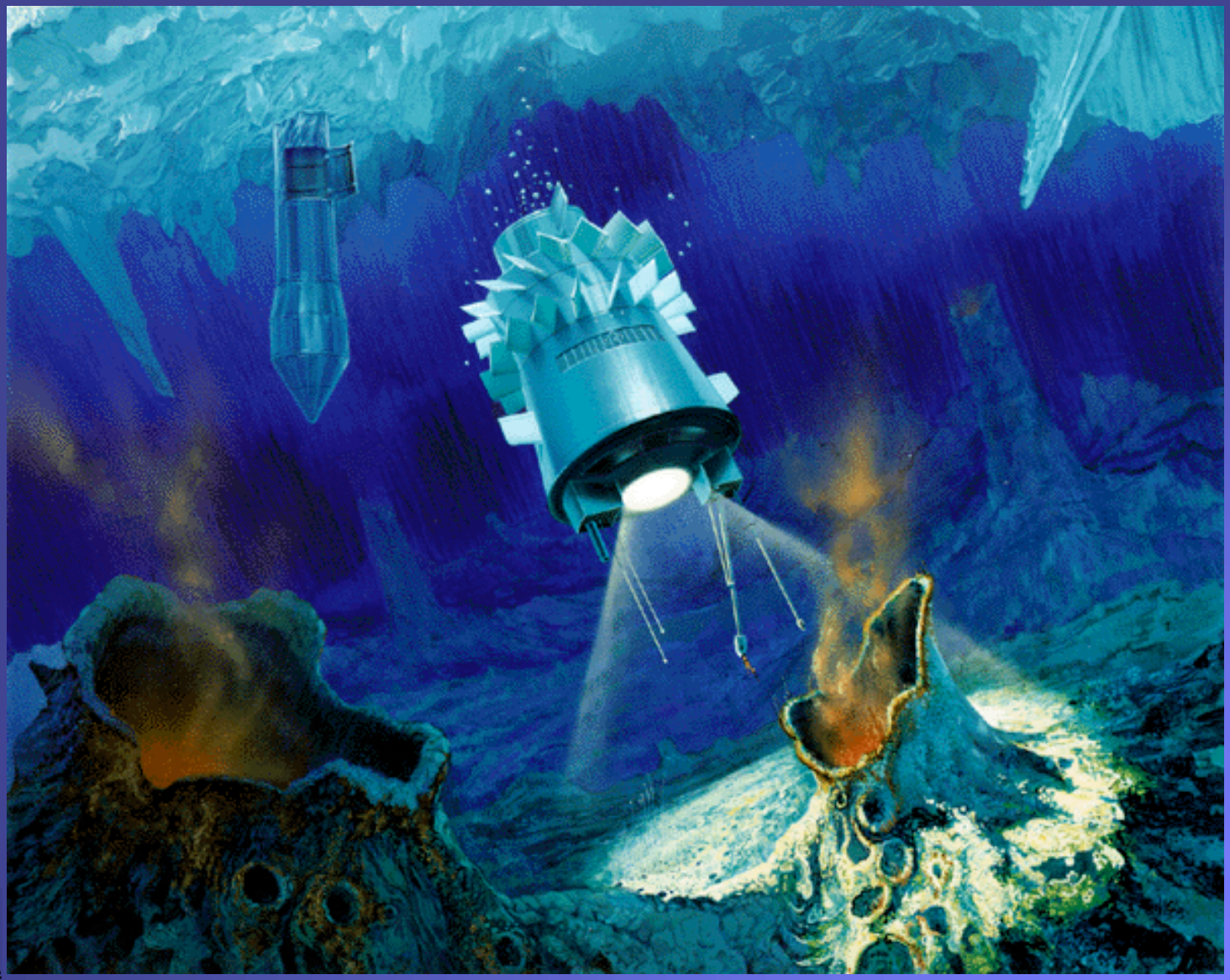
Challenge: Program Schedule

- Year 1 (2004)
  - Interface definition between robot arm and SeaBED
  - Modify/build new SeaBED for investigation (outside funding)
  - Design dexterous manipulators for 4000m submergence
  - Design autonomy approaches to vent sampling
  - Test prototype actuators in test chambers
  - (Target of opportunity) APOGEE Arctic field trials
- Year 2 (2005)
  - Assemble and test sampling arm
  - Integrate arm on SeaBED
  - Field trials off Woods Hole
  - APOGEE and SeaBED Arctic field trials
- Year 3 (2006)
  - Validate autonomy approaches
  - Field operations on Gakkel Ridge (summer)

Challenge: Ship Scheduling

- USCG Healy
  - 410 feet
  - 16,300 tons
  - Accommodations for 35 researchers
- Tentatively planned for Eastern Arctic in summer 2005
- Optimum scheduling for Gakkel Ridge is summer 2006
- May have to extend to 2007 to get Healy
- Other options exist:
  - Canadians
  - Germans
  - Russians

Mission Relevance: Europa



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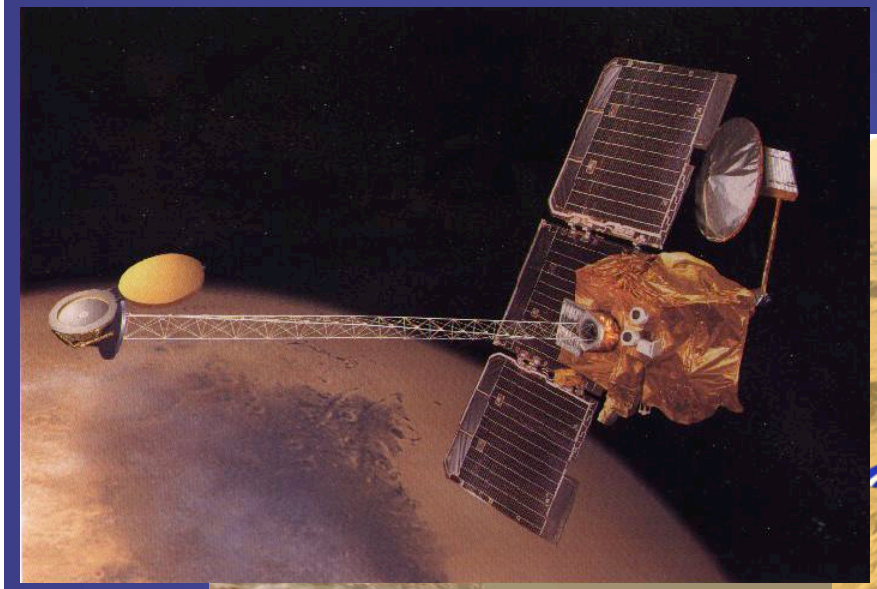
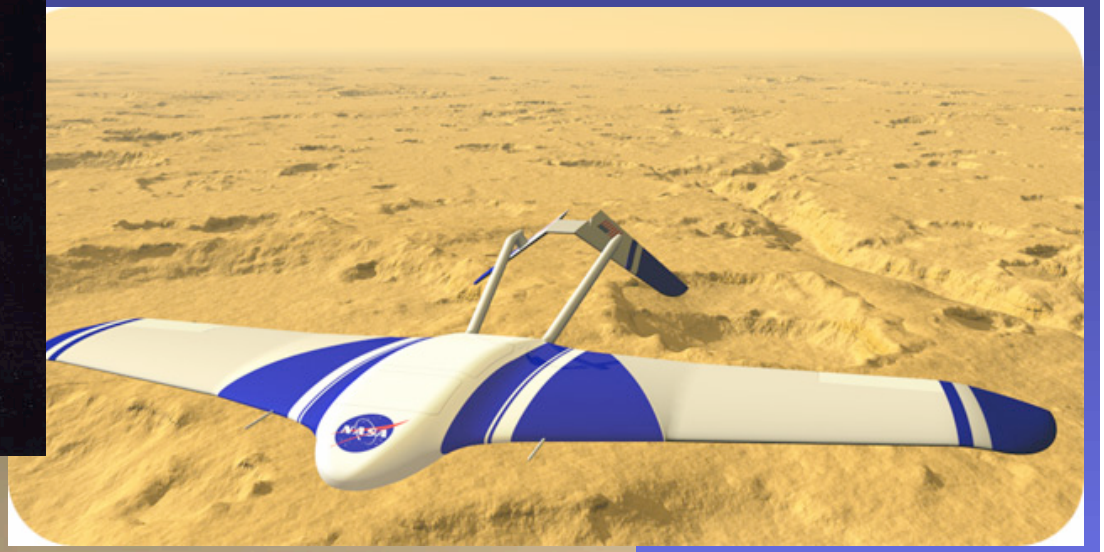
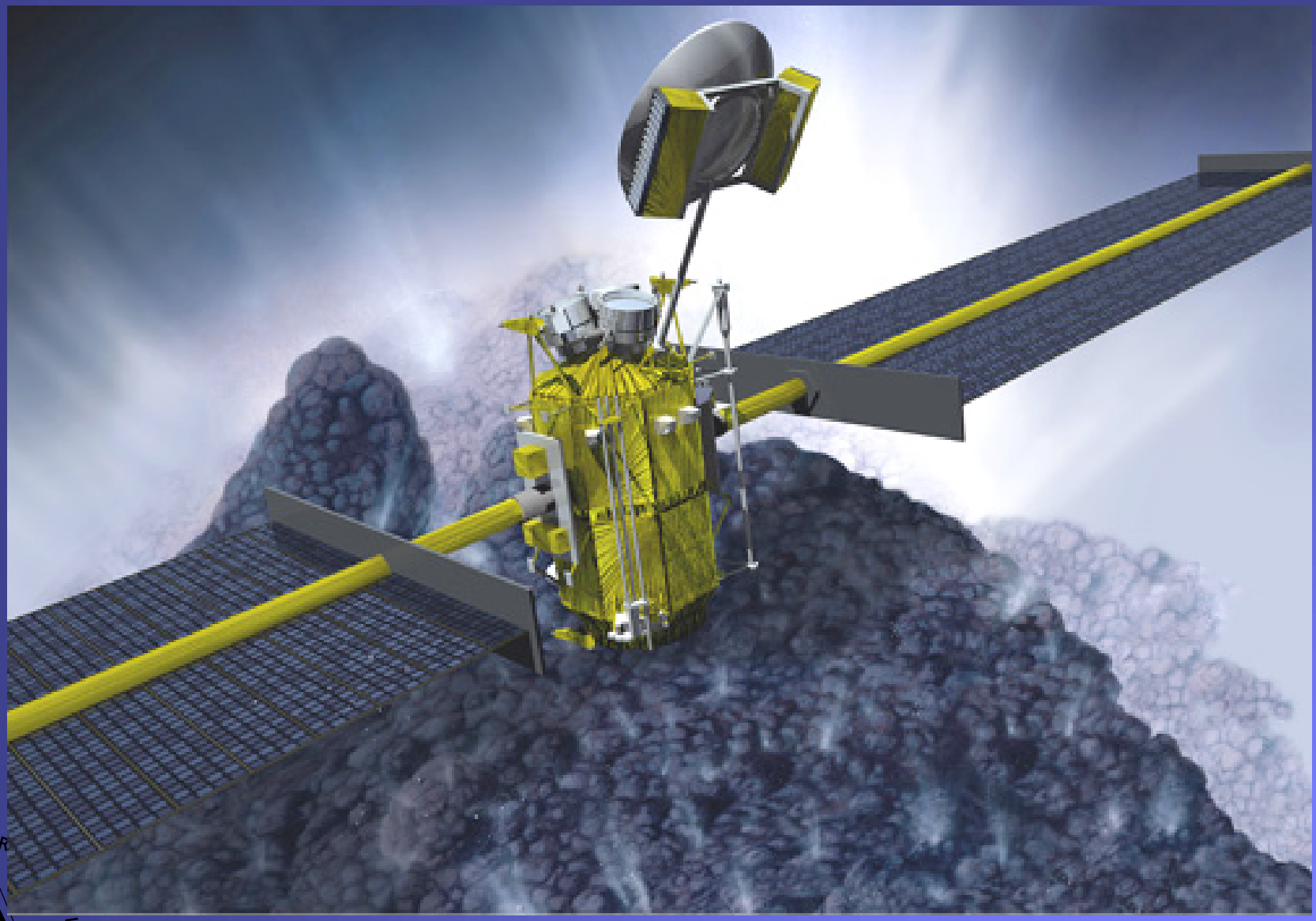
Mission Relevance: Mars





Mission Relevance: Comets/Asteroids



For More Information